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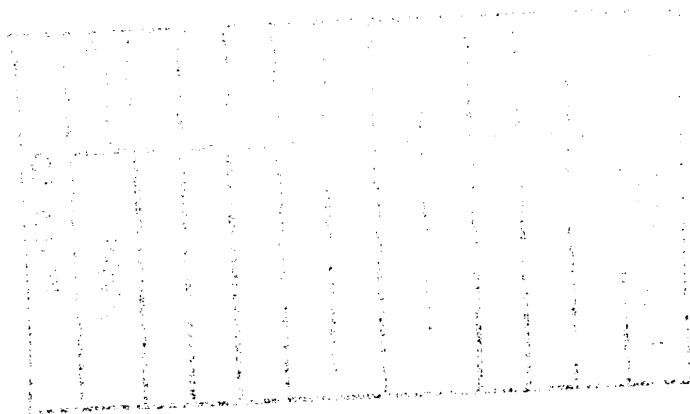


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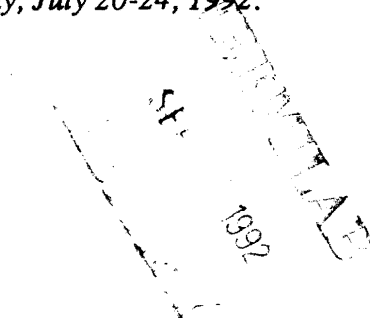
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DIRECT GENERATION OF MULTI-BUNCH WITH THERMIONIC GUN

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ABSTRACT

We report on the development of a multi-bunch thermionic gun for use at the Accelerator Test Facility for the Japan Linear Collider. Double-pulse beam separated by 1.4 ns was successfully created with the pulse width less than 700 ps and the peak current 4.5 A.

1 INTRODUCTION

The Accelerator Test Facility (ATF) has been built at KEK as a development bench of the Japan Linear Collider (JLC) project (Fig. 1). Presently the ATF consists of a thermionic gun, three sub-harmonic bunchers (SHB, 119 / 238 / 476 MHz), two single-cell pre-bunchers and a traveling wave S-band buncher, followed by a high-gradient accelerating structure. Various experiments are planned for the gun, operations of high power klystrons, acceleration of high-current, single- or multi-bunched beams with high-gradient structures, low-level RF devices, as well as the control system. A design study is under way to expand this facility in the near future, and to incrementally build a chain of a 1.5 GeV linac, a low-emittance damping ring, and a bunch compressor [1].

The thermionic electron gun described in this paper uses a

dispenser cathode with the area of 2 cm^2 (EIMAC Y-796), operating up to 240 kV. It has been successfully generating a single-bunch, high-current beam with a short pulse width [2]. The beam was accelerated with a high-gradient structure over 80 MV/m.

At the JLC the gun is required to generate multi-bunch beams without any satellite pulses to achieve the design high luminosity at the interaction point. As a first step towards this goal we have fabricated a grid pulse generator (GPG1) which can generate double pulses, 1.4 ns apart, with a small width. It consists of two fast avalanche pulse generators and an RF power combiner. Operating with a small power consumption, this pulse generator can easily vary the amplitude of each pulse independently, as well as their time spacing.

One drawback is that the power loss in the RF combiner must be kept small enough to generate many pulses. For example, to create a pulse train with 20 pulses the loss must be -18dB. This appears to be difficult to achieve. Consequently we have decided to develop another type of a grid pulse generator (GPG2) that consists of a fast ECL logic and an RF power amplifier. This circuit should be able to generate > 20 bunches/train. In this paper we describe the performance of the GPG1, experimental results of beam emission with this GPG1, and prospects for the development of GPG2.

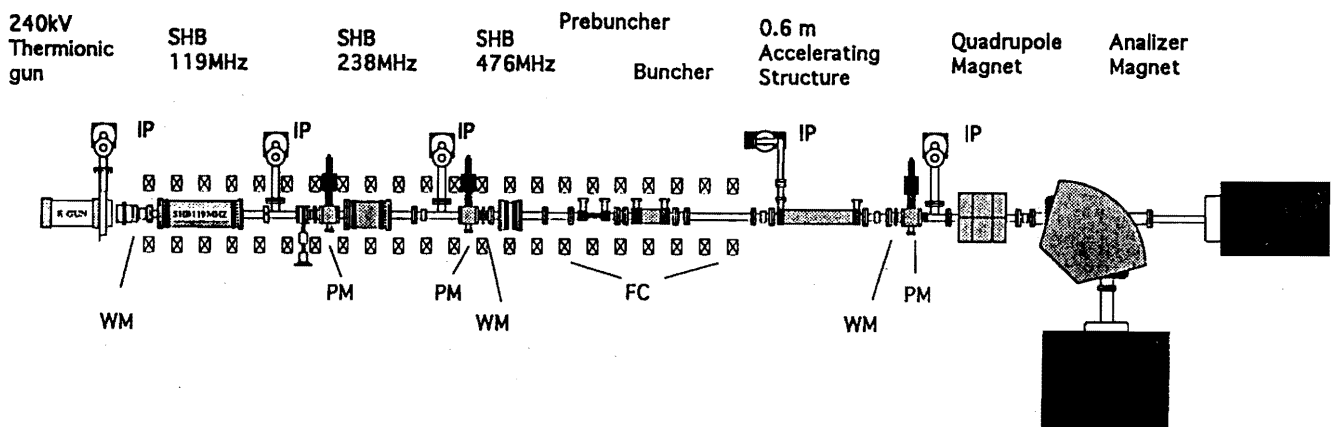


Fig. 1 Layout of ATF.

IP: Ion pump, WM: Wall current monitor, PM: Profile monitor, FC: Focus coil.

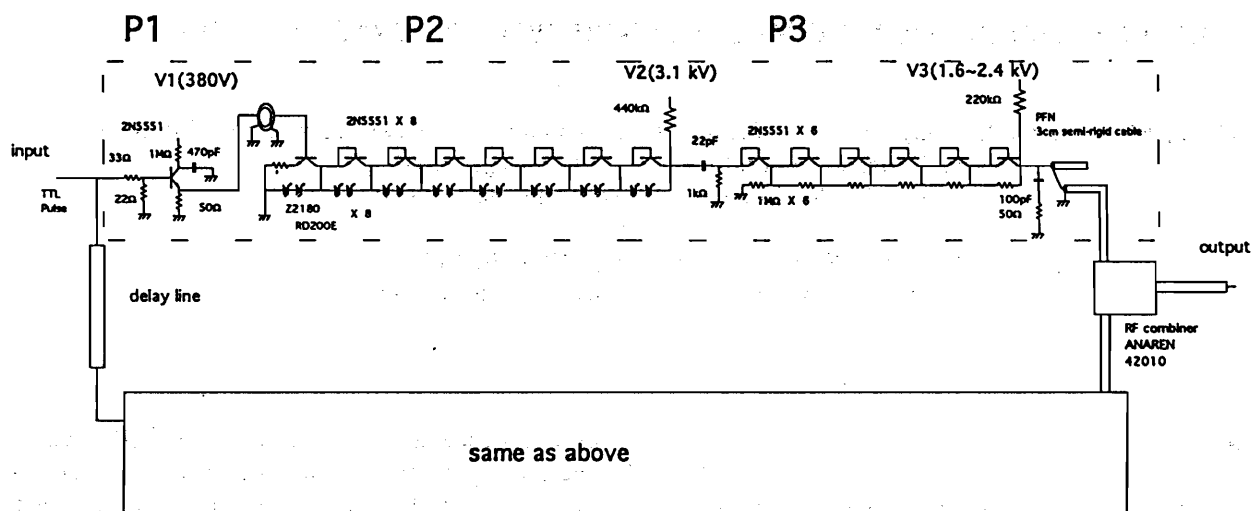


Fig.2 Schematic diagram of the double pulse generator

2 AVALANCHE TRANSISTOR PULSE GENERATOR

In earlier experiments at ATF a single-bunch beam was generated with a fast pulse generator built by Kentech Instruments Ltd. It employs an Avalanche Transistor Pulse Generator (APG) technology that has been originally developed for the sweeping circuit of CRT streak cameras [3,4]. We have extended the APG technology in the development of GPG1. Figure 2 shows the circuit diagram of a Fast Avalanche Pulse Generator (FAPG). It consists of three pulse generators P1, P2 and P3. The P1 is a single stage APG which boosts the input signal and reduces the rise time of the output signal. The P2 is an eight-stage APG to further boost the pulse. Although its output rise time (1 - 2 ns) is not short enough, its output amplitude is well over 800 V. This allows to drive the P3, a six-stage APG, to create a short output rise time (200 - 300 ps). The final pulse shape is formed with a PFN circuit and it results in a 500 ps full width, when a 3 cm semi-rigid cable is used. The amplitude of each pulse can be adjusted by 20 - 30 % by varying the charging voltage (V3) at the output stage. A typical pulse shape is shown in Fig. 3. The peak pulse amplitude and the width were ~ 500 V and 500 ps.

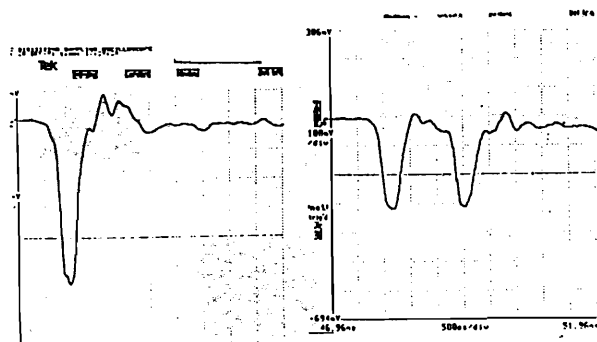


Fig.3 Output of the FAPG (100V/div, 500ps/div)
Fig.4 Output of the double pulse generator (100V/div, 500ps/div)

The double pulses are formed by using two FAPGs and a RF combiner. To create two output pulses, the input for each FAPG is triggered at a different timing using a delay line. The pulses from each FAPG are delivered to the RF combiner, whose output signal is shown in Fig. 4. The peak amplitude of each pulse and the pulse width are ~ 300 V, and 500 ps, respectively. The reduction in the amplitude is due to the power loss at the RF combiner.

3 EXPERIMENT WITH DOUBLE-PULSE GENERATOR

In this experiment trigger signal to the gun is synchronized to one-sixth of the S-band frequency (476 MHz) using a synchronization circuit TD-2 that had been developed for TRISTAN [5]. The total time jitter was measured to be 30 ps at the output of the grid pulse generator. The beam shape and the intensity were monitored right downstream of the gun with a wall current monitor with a fast beam response (~ 200 ps) [6]. The position dependence of the monitor was corrected for comparing the signals from four port outputs. The emitted beam is shown in Fig.7. The peak current was measured to be 4.5 A (1×10^{10} electrons/bunch), the pulse full width ~ 700 ps, and the pulse spacing 1.4 ns. The peak current of the emitted beam appears to be limited to about 1/2 of the space charge limit as predicted by the program ETP [7]. We believe that this is because 1) the amplitude of the grid pulse is not sufficiently high to obtain a high beam current, and 2) the vacuum 2×10^{-8} Torr is not sufficiently low for the cathode. If the grid pulse generator had larger amplitude and if the ability of the ion pump is improved, a higher peak current would be emitted. This emitted beam is not yet accelerated. individual phase control of the beams needs to be built for this test.

4 MULTI-PULSE GENERATOR

Fast ECL logic + RF power amplifier

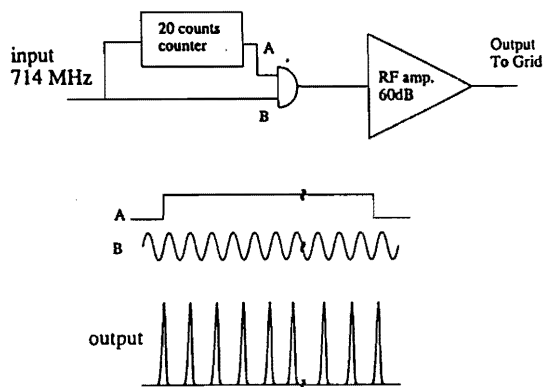


Fig 5 Schematic drawing of multi pulse generator.

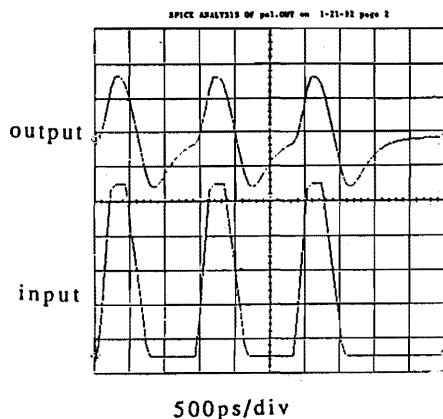


Fig. 6 Pulse response of the RF amp. of the multi pulse generator

As mentioned earlier, it is difficult to generate more than 20 pulses per pulse train with a GPG1-type grid pulse generator. Use of fast ECL circuits and the RF amplifier is a promising candidate for an alternative solution. Fig. 5 shows the block diagram of this scheme. A 714 MHz RF signal, synchronized with the frequency of the accelerating structure, is used as a clock signal to the ECL circuit. The required number of pulses were formed by counting and gating the RF signals in the circuit. The selected pulses are amplified by an RF power amplifier. To obtain a sufficiently large output signal the RF amplifier is required to have a power of ~ 10 kW and the gain 60 dB. Fig.6 shows the simulated response of the RF amplifier, calculated with the computer code SPICE. At present the first prototype ECL circuit is being fabricated. It will be tested shortly.

4 SUMMARY

We have successfully generated double-pulse beams with $\sim 1 \times 10^{10}$ electrons/bunch and with 1.4 ns spacing with a thermionic gun driven by a pair of Avalanche Grid Pulsers (APG). The beam will be used for the study of a 1.5 GeV linac

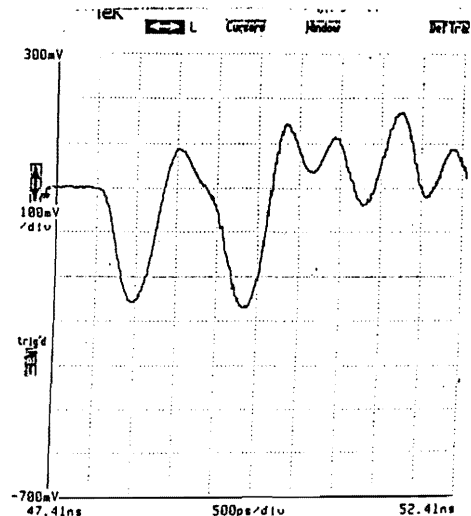


Fig 7 Wave shape of double bunches beam,
Anode voltage: 150 kV, Heater voltage: 6.2 V, Net drive voltage: 286 V, Vacuum 2×10^{-8} Torr

and a damping ring. Such a APG technology will be useful for many thermionic gun applications.

In order to satisfy the JLC parameter requirements, we have started developing of a multi-pulse generator using a fast ECL circuit and an RF power amplifier.

ACKNOWLEDGEMENTS

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REFERENCES

- [1] J.Urakawa et al., in this conference.
- [2] T.Naito et al., "Single Bunched Beam Generation using Conventional Electron Gun for JLC Injector", Proc. of the 1991 Particle Accelerator Conference, San Francisco (1991)
- [3] D.M.Benzel et al., "1000-V,300-ps pulse-generation circuit using silicon avalanche devices", Rev. Sci. Instrum. 56(7) July 1985
- [4] J.D.Hares, "Advances in sub-nanosecond shutter tube technology and application in plasma", SPIE Vol. 831 X Rays from Laser Plasmas(1987)
- [5] K.Ishii, "DIGITAL DELAY CAMAC MODULE WITH 550MHz PRESET COUNTER(TD-2)", KEK report 83-14 (1983)
- [6] T.Naito et al., "Short bunch beam monitor", 8th Sympo. on Accelerator Science and Technology, Saitama, (1991)
- [7] W.B.Herrmannsfeldt, "EGUN-AN ELECTRON OPTICS AND GUN DESIGN PROGRAM", SLAC report 331,(1988)